SPS Emittance Growth MDs

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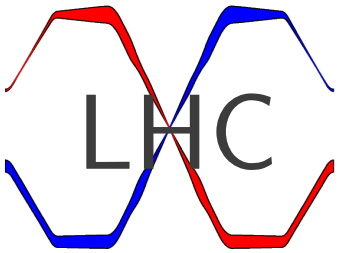
LHC-CC11, Nov 14-15, 2011



- Motivation
- Experiments 2009-2011
- Outlook

Big Thanks: SPS-OP &
W. Hofle, E. Shaposhnikova

→ LHC-CC09, Action Item:

Evaluate the difference between electron & protons with crabs

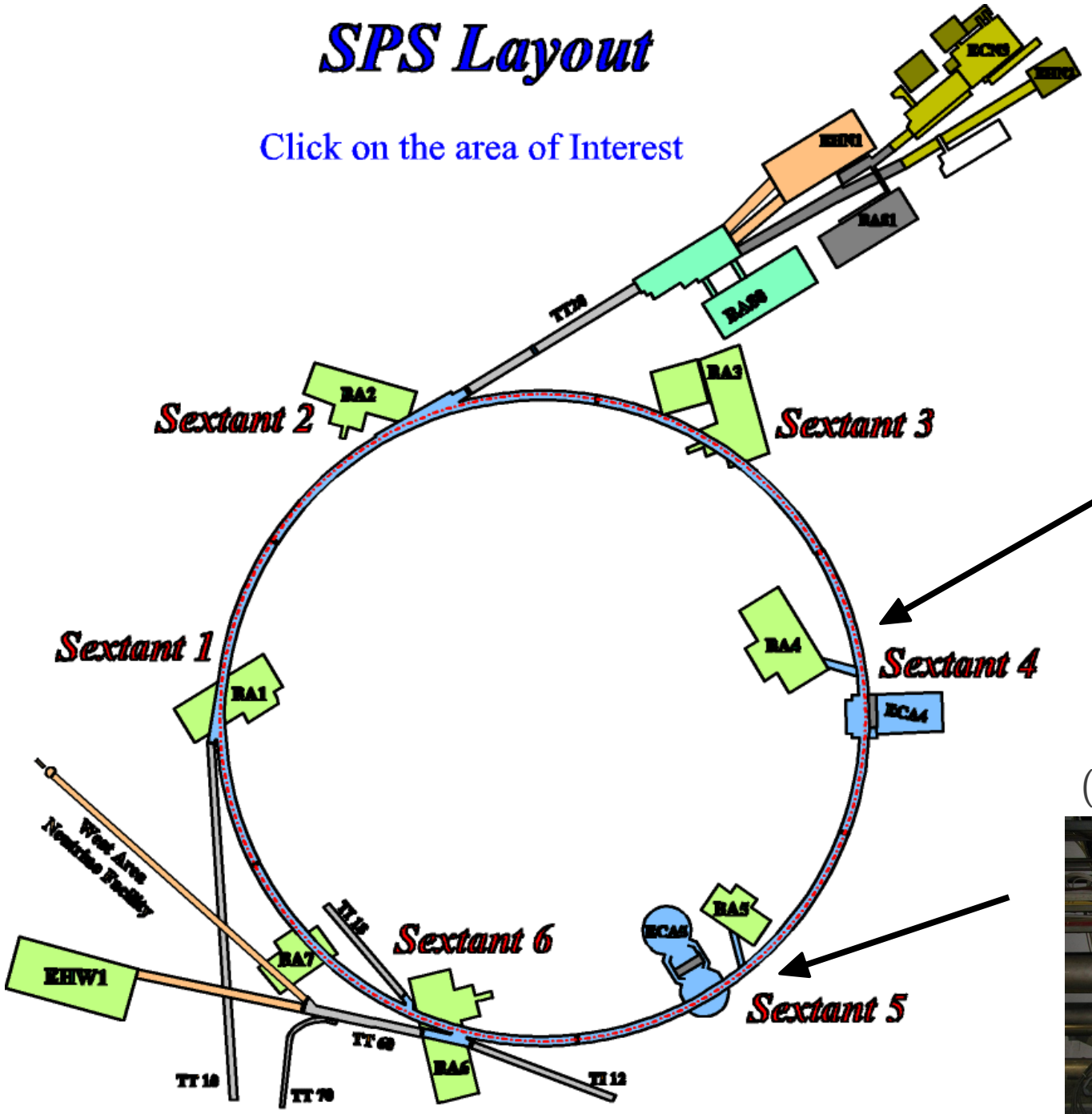
→ LHC-CC10, follow-up action Item:

Source of the SPS natural emittance growth to be identified

→ Actions performed:

Beam studies at 55 GeV, 120 GeV & 270 GeV coasts

Simulations to support experimental observations (see H.J.Kim)

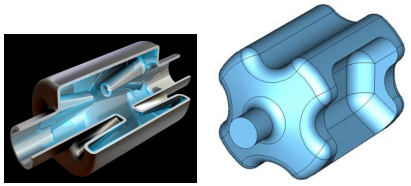


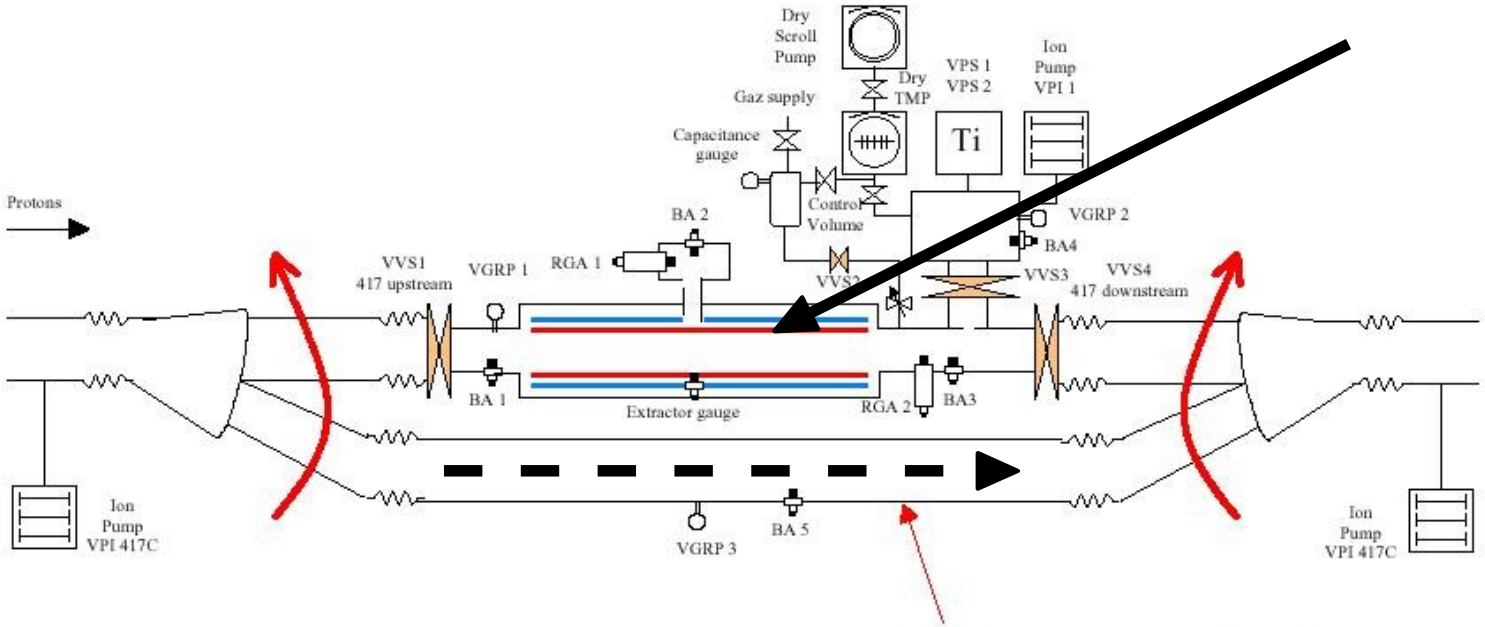
LSS4, COLDEX Dogleg

BWS519 H/V

(Rotational Wire, 6 m/s)

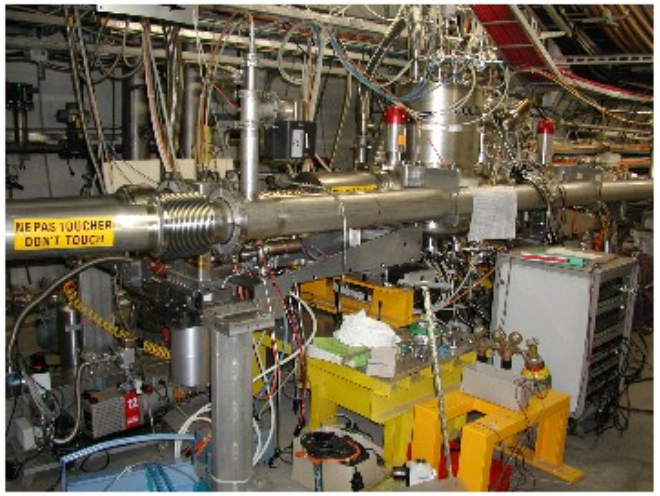
SPS As a Testbed

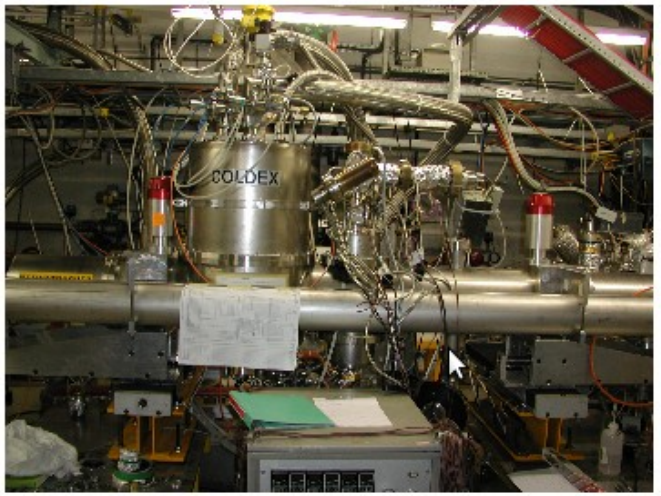


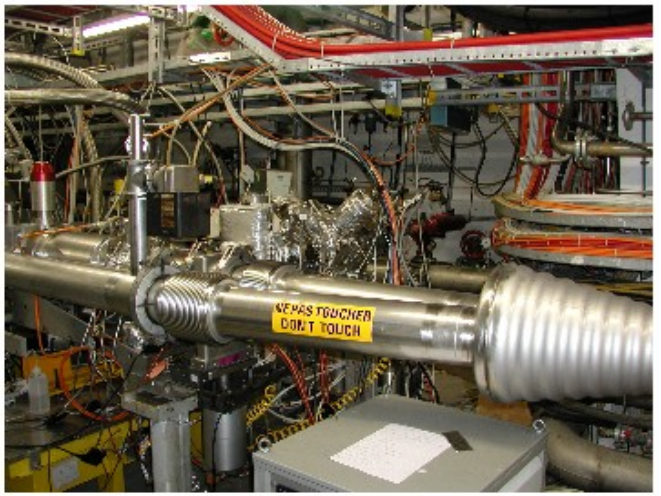


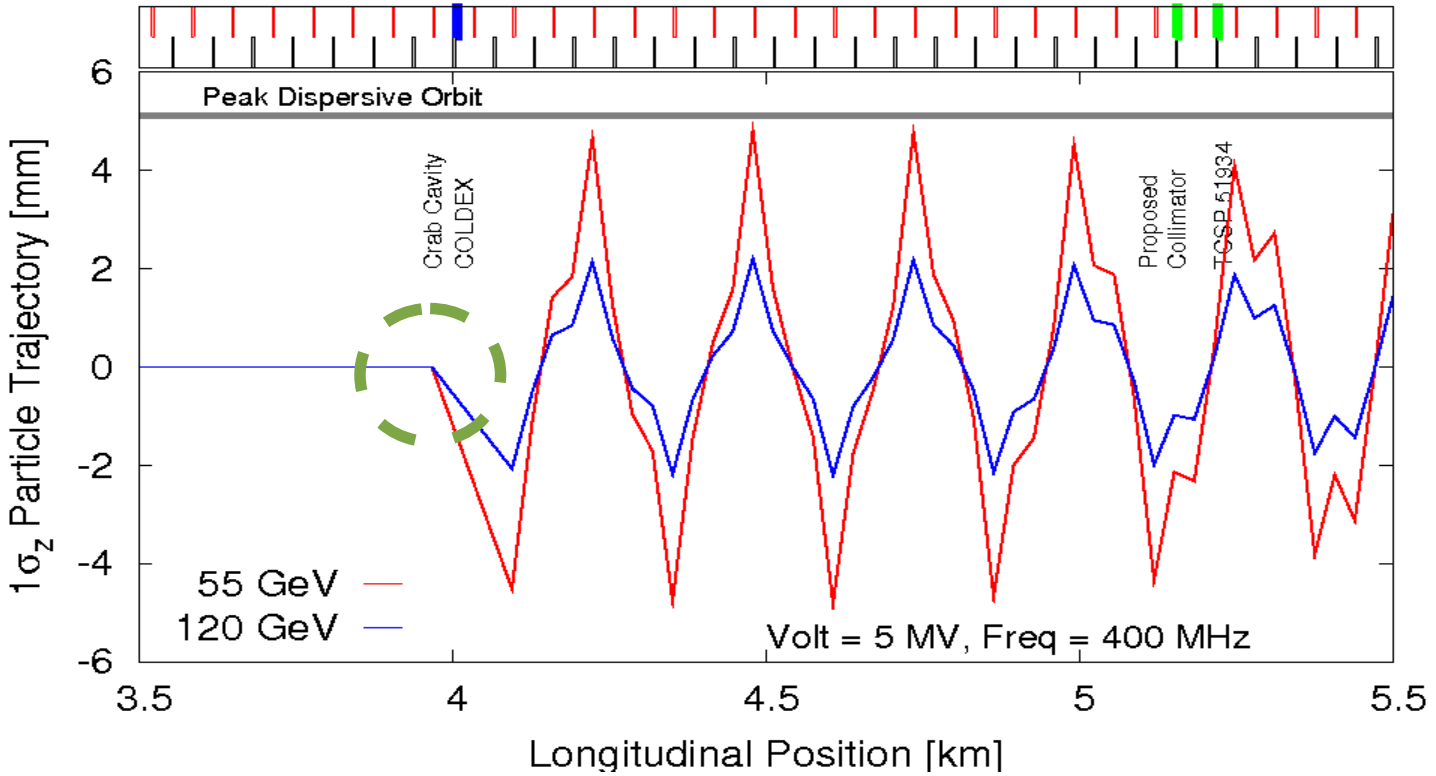
Energy	55, 120, 270 GeV
Longitudinal Position	4020 m +/- 5m
Total length	10.72 m
βx, βy	41.559m, 58.604m
Qx, Qy	26.12, 26.18
Dispersion	-0.58 m

LSS4, COLDEX









Remember

RMS orbit in SPS ~3-4 mm

May have to depend on:

- Headtail monitor
- Wideband pickup
- Schottky(?)

SPS Studies So Far

Emittance growth studies (2010 & 11) to determine appropriate energy

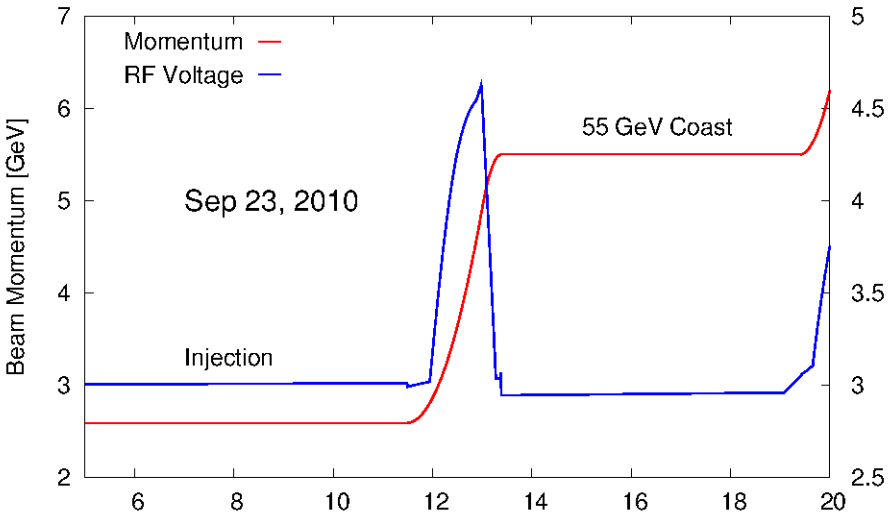
→ Q26: 55, 120, 270 GeV natural emittance growth

→ Q20: First trial at 270 GeV, somewhat unsuccessful

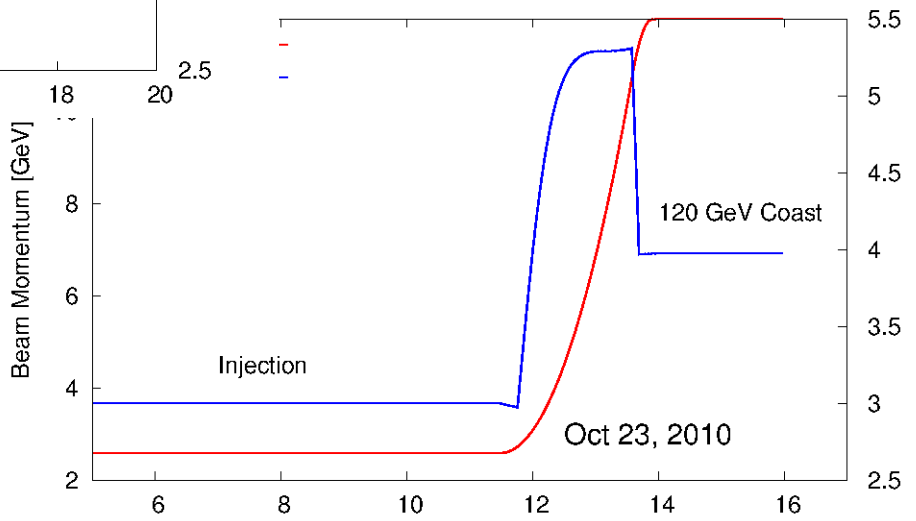
Simulations are being performed to understand source (H. -J. Kim)

	Unit	Sep 2010	Oct 2010	May 2011	July 2011
Energy	GeV	55	120	120	270
Qx,y	-	0.13/0.18	0.13/0.18	Several tunes	0.13/0.18
ξx,y		2-3	2	0.5	0.5
Intensity	x 10^{11}	1.1	0.5	0.2	0.2
# Bunches	-	1	12	1	1
$\varepsilon_{x,y}$	μm	3.1/2.8	1.5-2.0	2.5	2.5
V_{RF}	MV	3.0	4.0 (1)	4.6 - 6.5	4.6 - 6.5

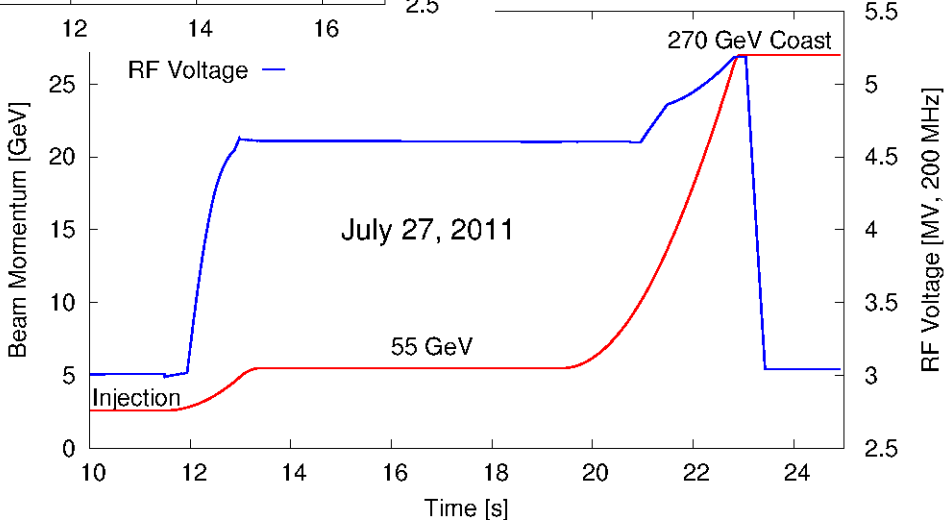
Energy & RF Setup



55 GeV Coast

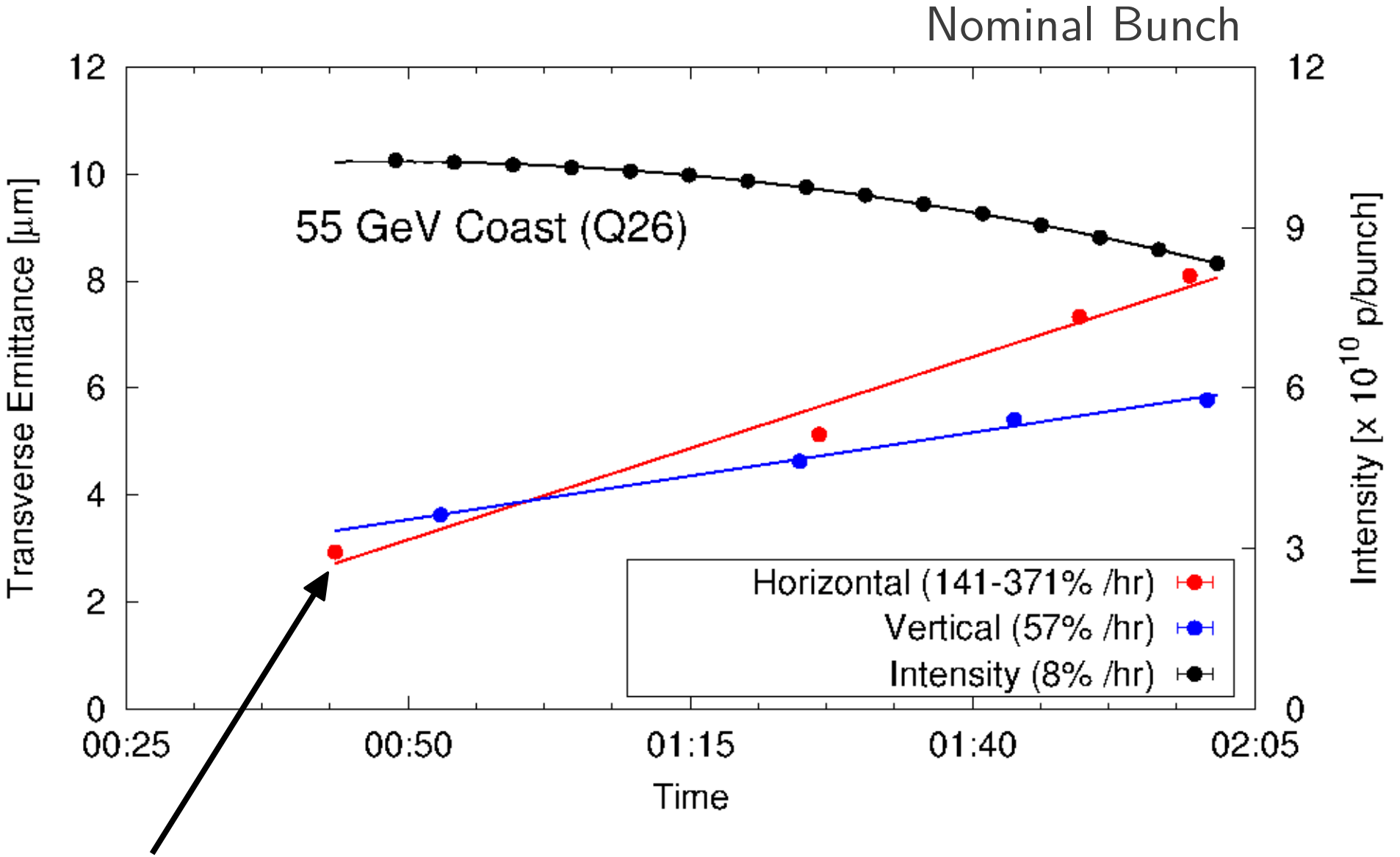


120 GeV Coast



270 GeV Coast

SPS MD, 55 GeV



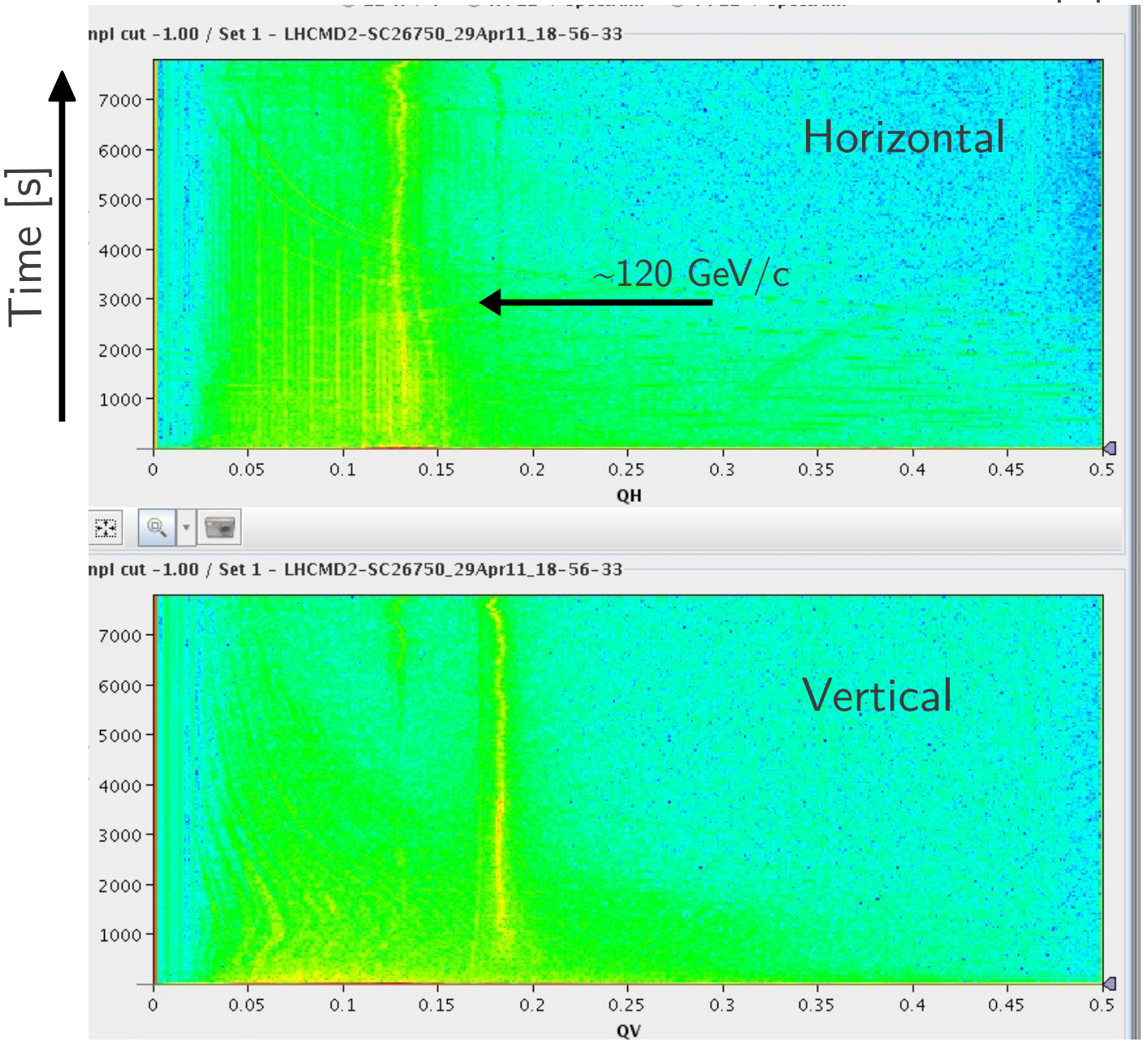
Including this point
makes a huge difference

Try low bunch intensity (E. Shaposhnikova)

Lets try higher energy $\rightarrow$ 120 GeV

Tune Measurement, Q20 Cycle

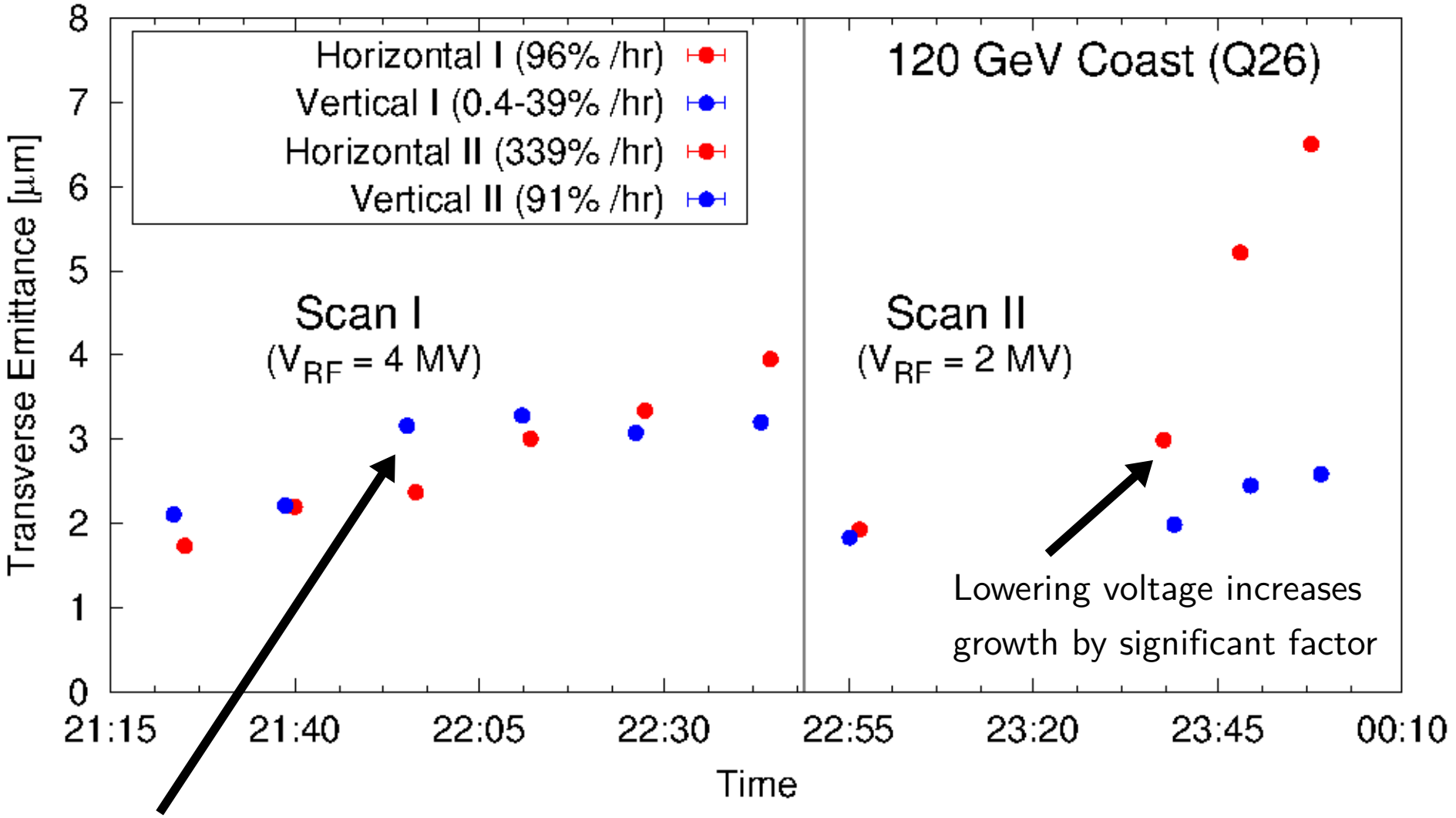
Yannis Papaphilippou, May 24, 2010 (MD2)



Lots of activity
until ~200 GeV

SPS MD, 120 GeV

0.5×10^{11}, 12 bunches

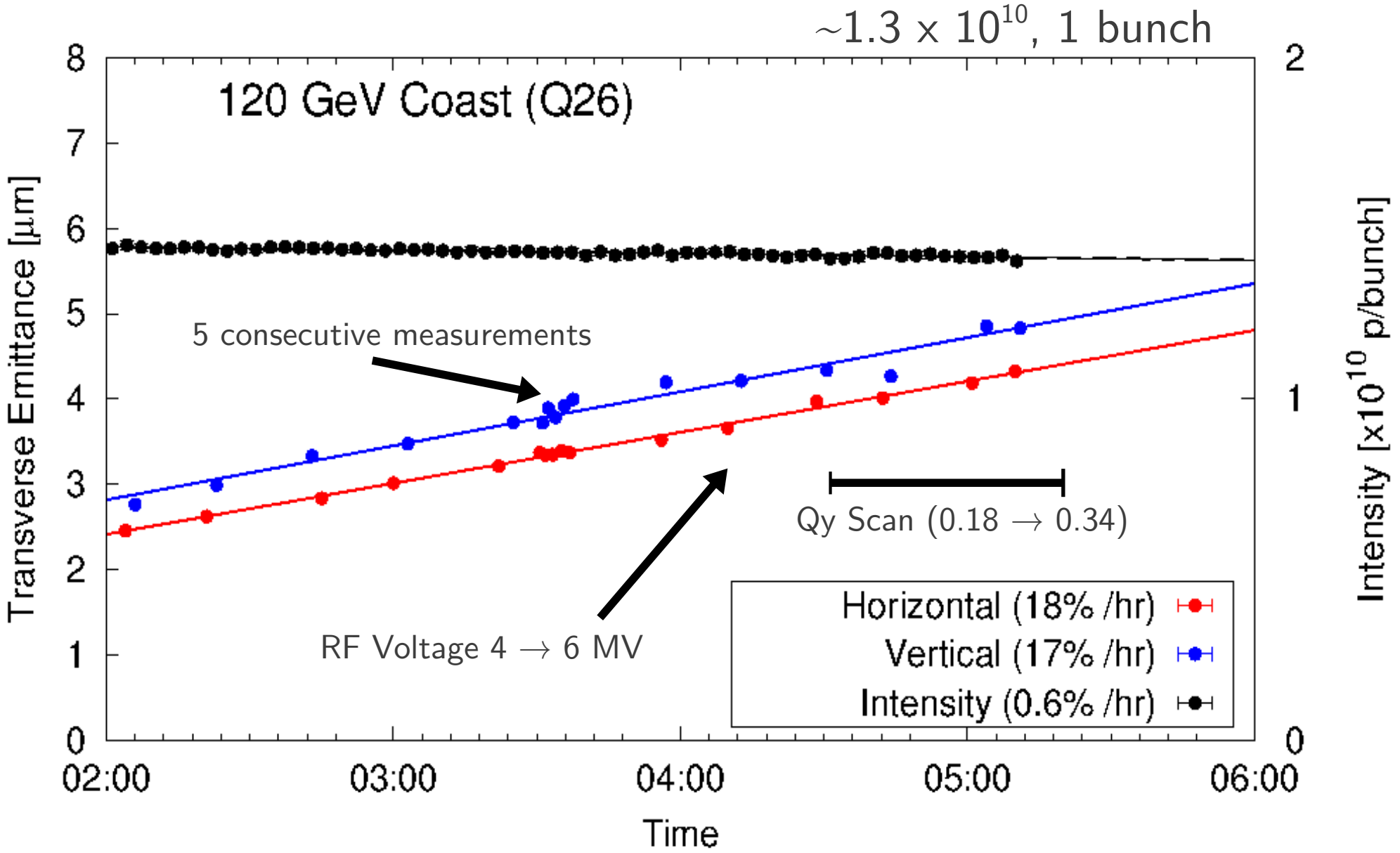


Lowering voltage increases growth by significant factor

vertical wire stuck

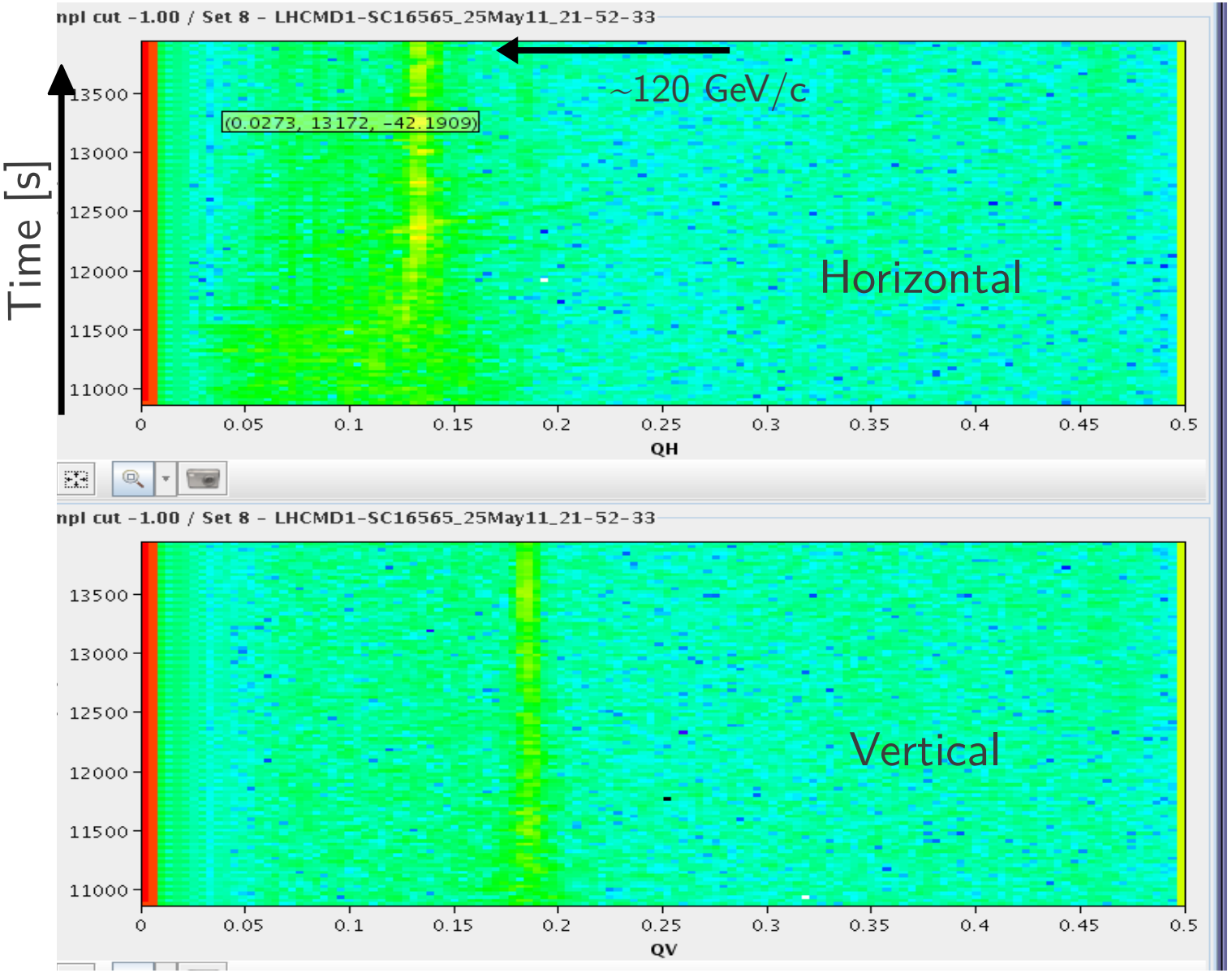
IBS calculations from MADX predict that growth gets smaller

SPS MD, 120 GeV



Tune Measurement, MD

May 25, 2011

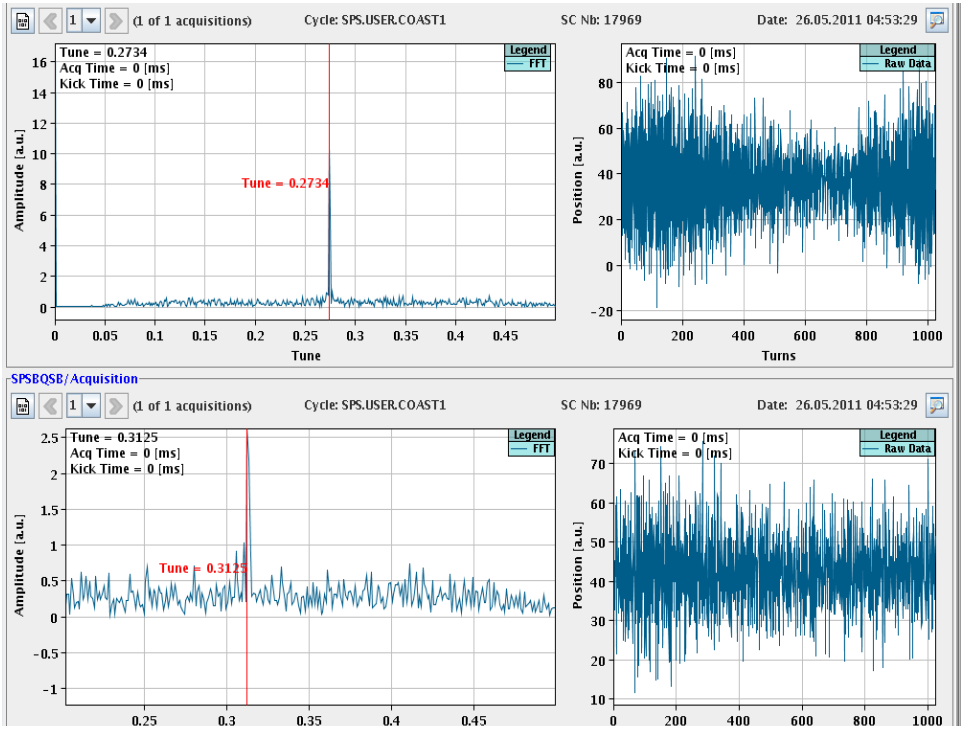


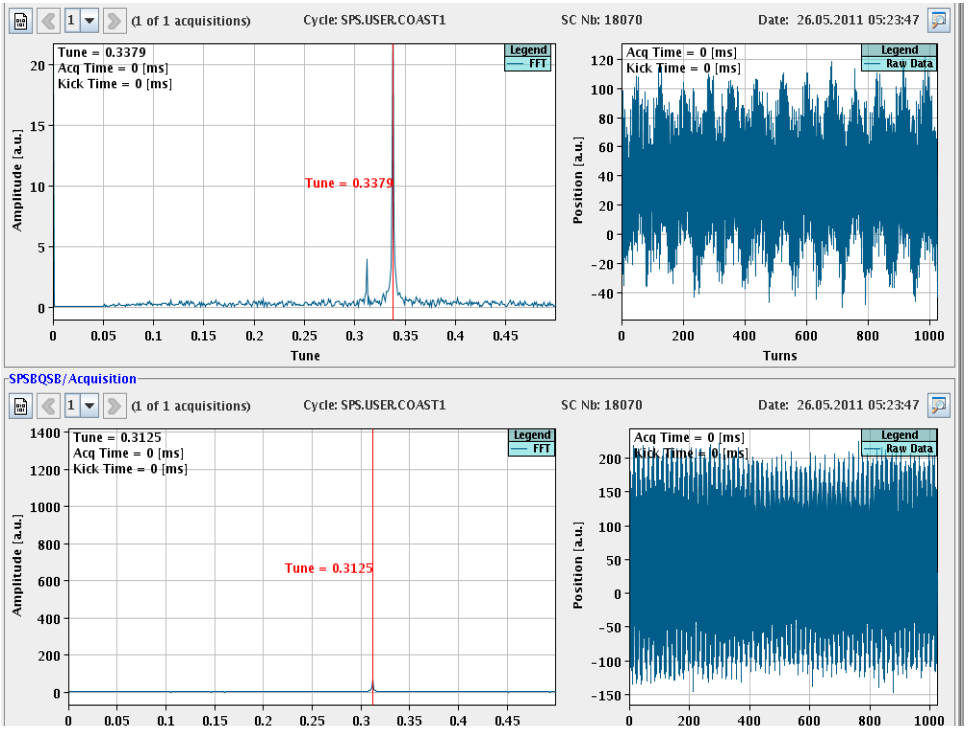
Tune activity different & quiet

Tune Scan, 120 GeV

Coherent dipole oscillations (ξ ~0 units), not unstable

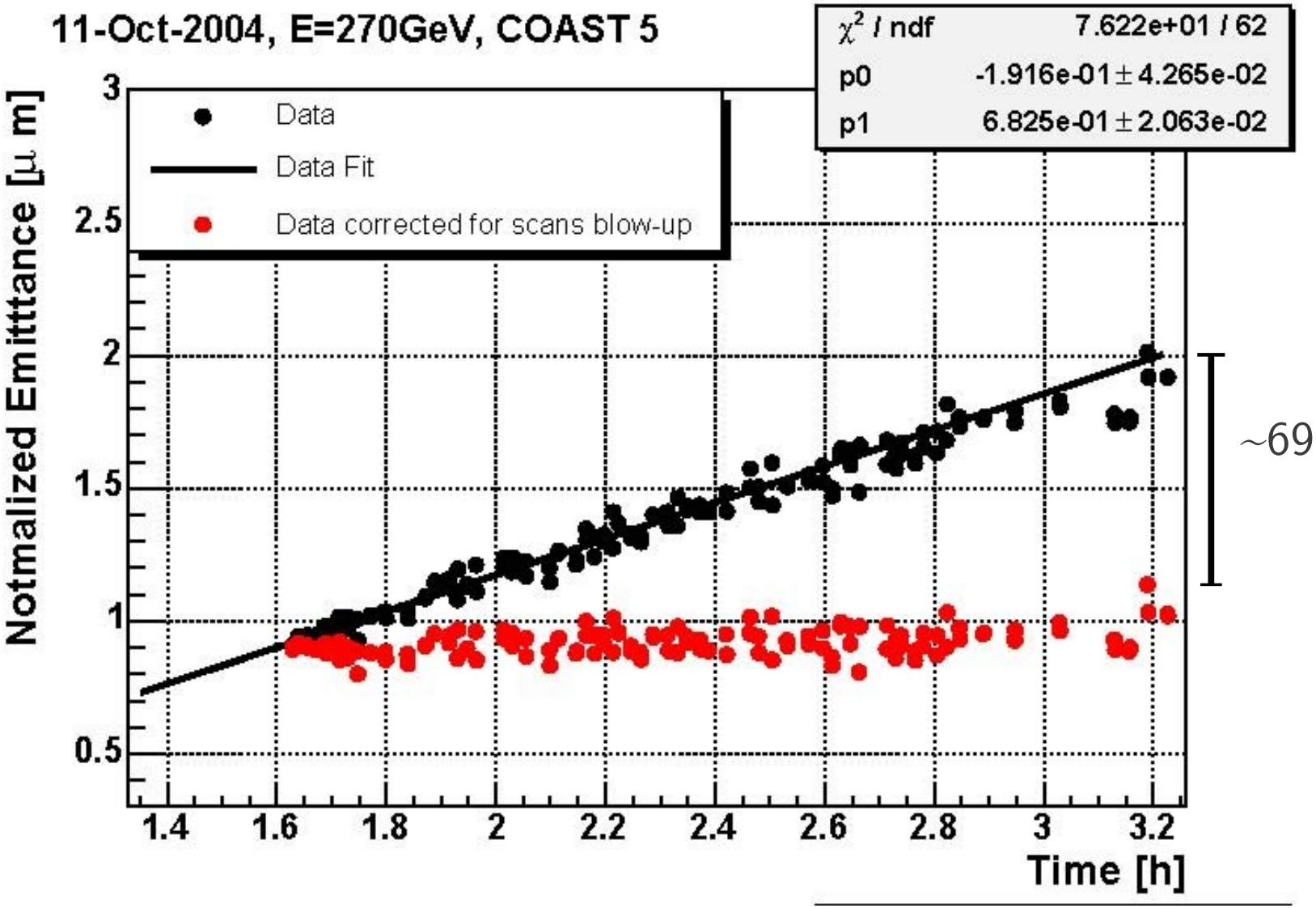
No change in slope during the tune scan





270 GeV in 2004

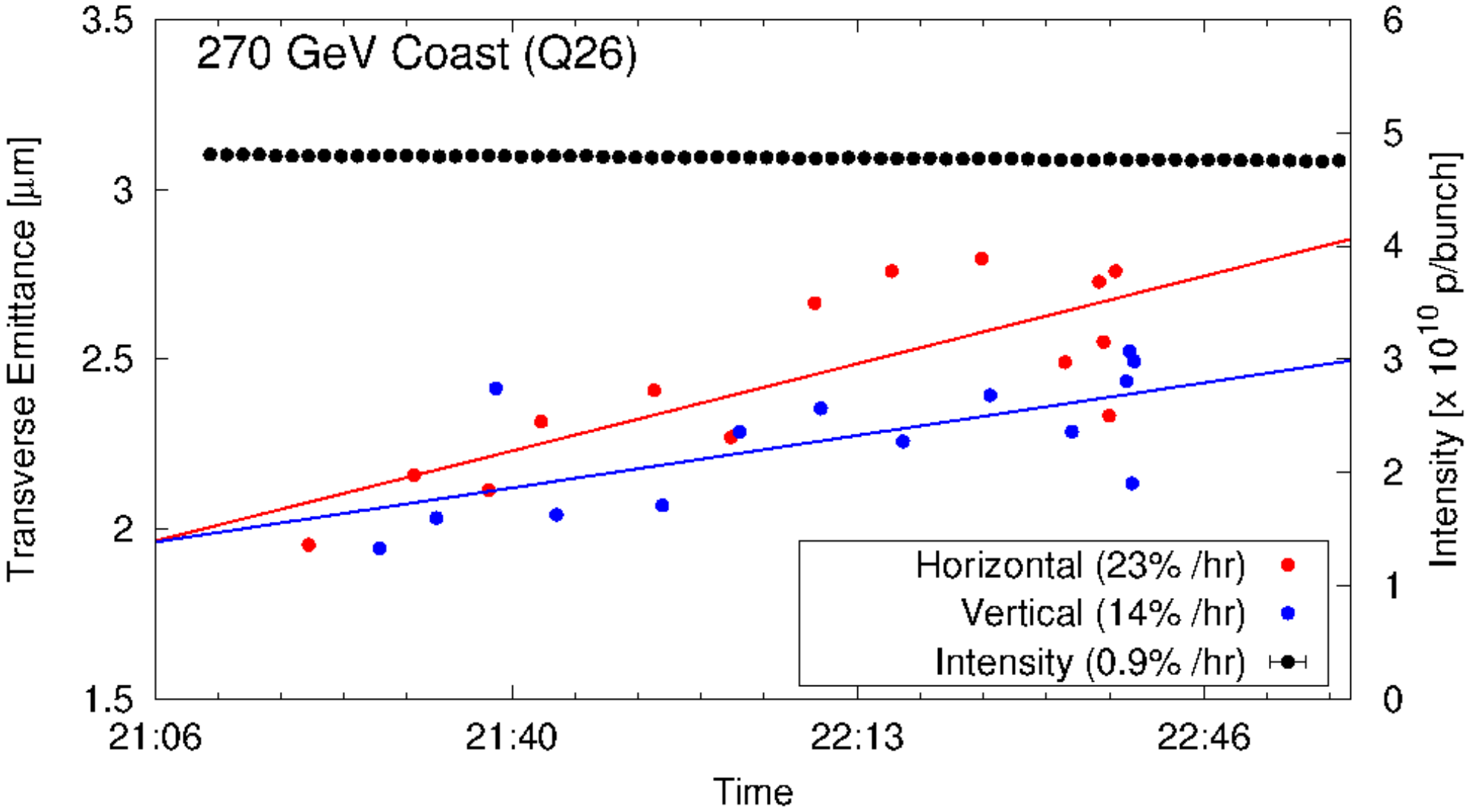
F. Roncarolo et al.



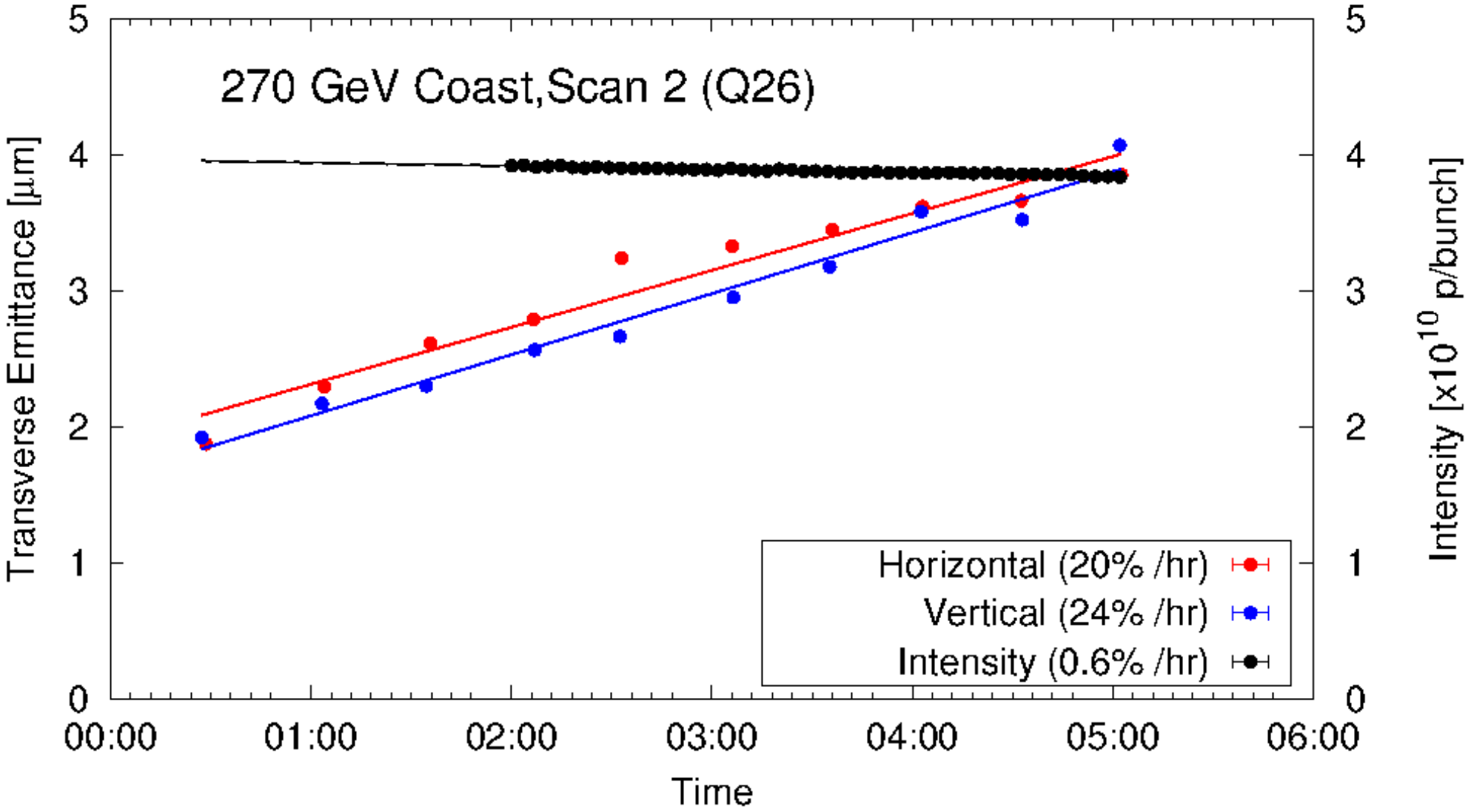
No emittance growth after wire scanner correction

~0.01μm/scan at 270 GeV (x2 worse at 120 GeV)

SPS MD, 270 GeV (Short)



SPS MD, 270 GeV (Long)



Emittance Growth Summary

Energy [GeV]	Intensity [x 10^{11}]	Qx/Qy	Voltage [MV]	$d\varepsilon_x/dt$ [/hr]	$d\varepsilon_y/dt$ [%/hr]
55	1.0	0.13/0.18	3.0	140-370%	57%
120	0.5 (12b)	0.13/0.18	2.0-4.0	100-300%	40-90%
120	0.1	0.13-0.33	2.0-4.0	18%	17%
270	0.4	0.13/0.18	3.0	20-23%	14-24%

Should we use the wire scan correction or is it included ?

Observations from other MDs

BBLR (G. Sterbini et al.)

55 GeV, 12 bunches, 0.5×10^{11} (LHC tunes)

Factor 2 or larger growth in 1 hr in both planes

Phase-II Collimators (D. Wollmann et al.)

120 GeV, 1 nominal bunch

Factor 4 in horizontal & 60% in vertical growth in 1 h

Decrease in BPM signals (perhaps de-bunching)

UA9, Crystal MDs (W. Scandale)

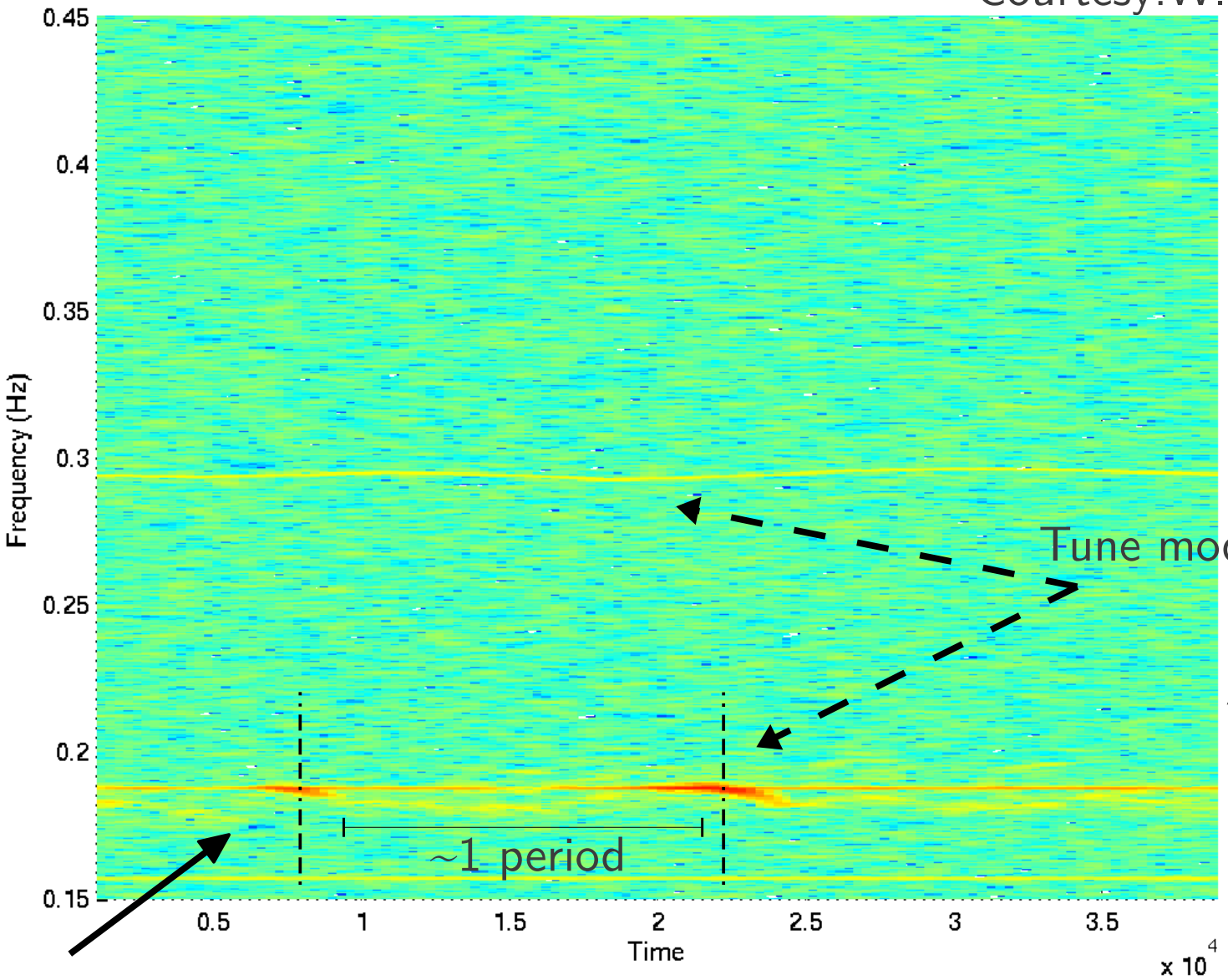
120 GeV, single nominal bunch

Factor 2 or more emittance growth in $\sim$2 hrs

Lifetime $<$ 10h (collimators at $\sim 6\sigma$)

Wide-Band Feedback MDs

Courtesy:W. Hofle et al.



Tune modulation visible

~600-700 Hz

$\Delta Q_y \sim 2 \times 10^{-3}$

Inject coherent signal

@sychrotron side-band

Conclusions

Transverse emittance growth

- Substantial emittance growth in coasts between 55-270 GeV
- Appears single bunch effect, lifetime worse than p-pbar
- Effect of the working point is minimal & RF voltage is opposite

Possible culprits

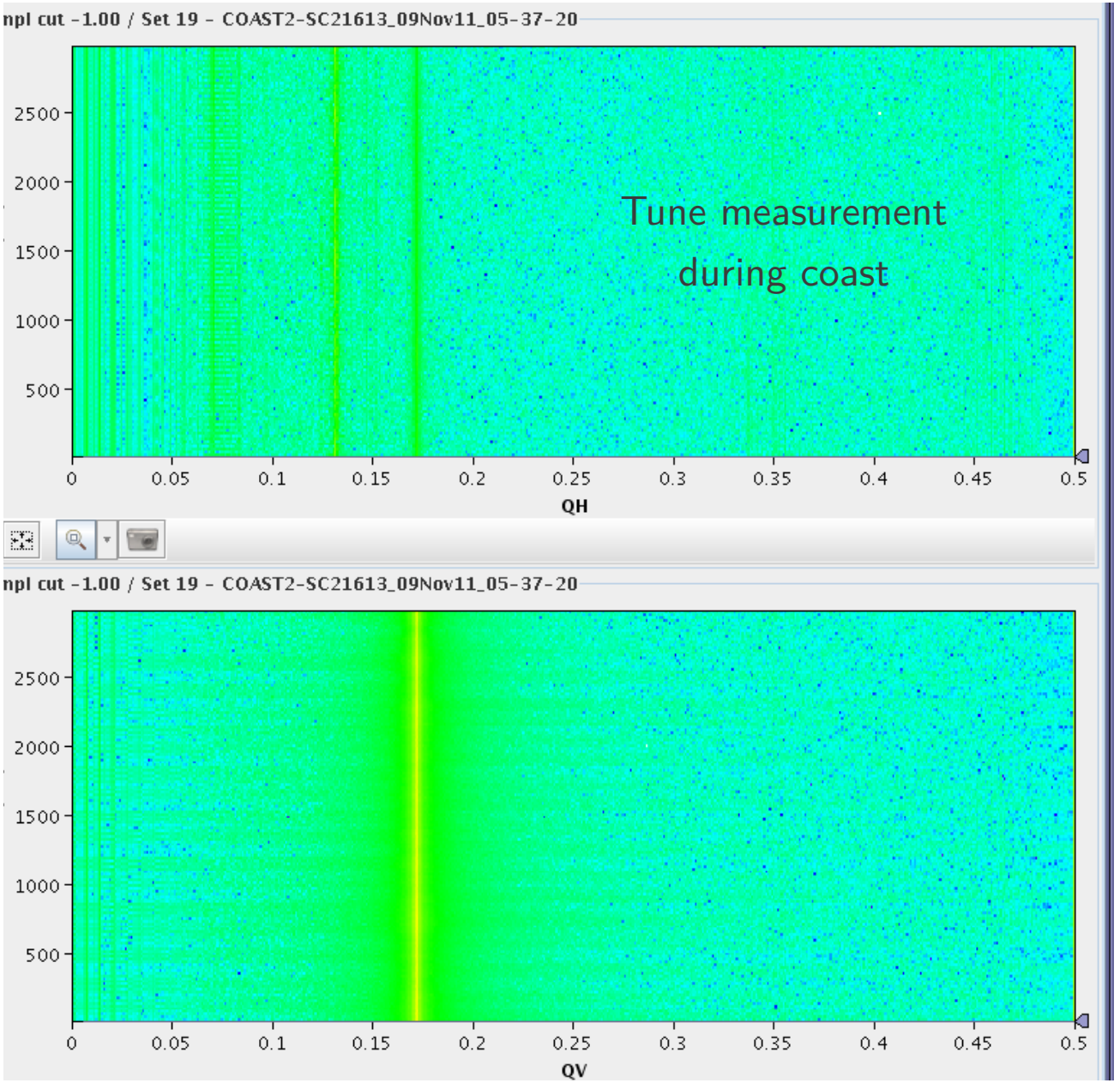
- Power supply ripple (dipoles, quadrupoles), vacuum ?
- Can we measure the ripple at the source and improve ?

Comments

- Transverse damper PU signals to be analyzed for coherent signals
- Schottky signals maybe available in 2013 (T. Bohl et al.)

All ideas are welcome

Q20 Lattice, 270 GeV



Low γT lattice

Starting emittance already large

RMS orbit quite large

Need to repeat with better setup

A1: SPS Test Objectives

Technology validation with beam

- Field and quench margins, RF controls, ramping, synchronization
- Beam measurements (orbits, tunes, emittances, optics, noise)
- Collimation, scrapers to reduction of physical aperture

High Intensity measurements

- Emittance growth, impedance measurements, instabilities
- Cavity stabilty, beam-loading and compensation, non-linearities
- RF and orbit feedback, detuning and retuning

Operational & failure scenarios

- Accumulation of beam with crab-on & crab off
- RF trips and effects on the beam
- Machine protection studies and appropriate interlocks

A3: Prelim Cryo

Heat load (1 module, 2 cavities)

- Static: 2 W (2K), 10 W (4K), ~100 W (LN2)
- Dynamic: 24 W (2K) $\rightarrow$ 5 MV transverse voltage
- Volume of the Helium vessel: ~100 L

Frequency tuning

- Static: ~1-2 MHz ?
- Dynamic range: ~100 kHz ?

RF power (Cavity $Q_0 > 1e9$)

- Qext: $1x10^6$, assume around 5-20 kW

Feedback

- RF feedback for phase/amplitude control
- Beam loading, 0.1-0.2 MV/mm (depends on the cavity)
- Orbit feedback (slow) $\rightarrow$ BPM resolution ~100 microns)